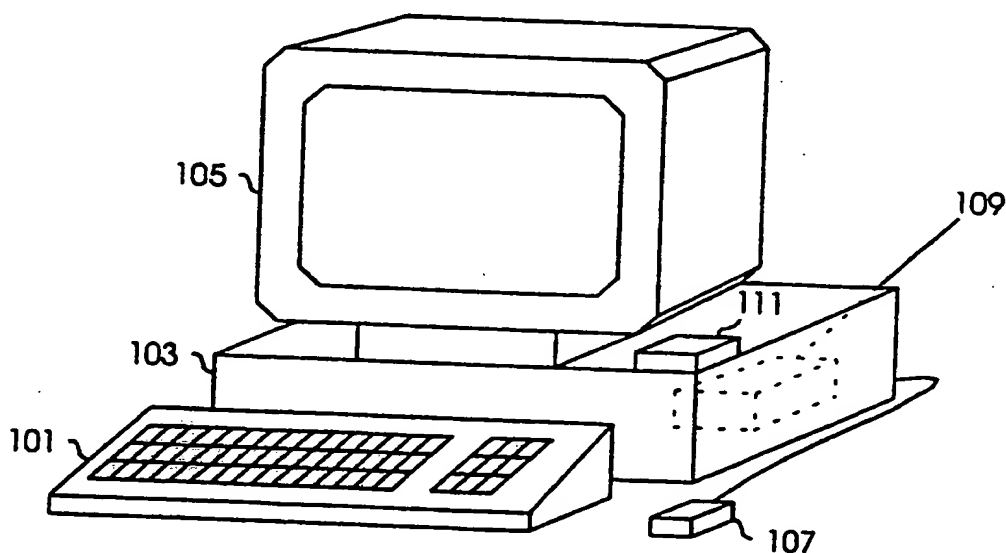




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(54) Title: PROTECTING PROGRAMS AND DATA WITH CARD READER



(57) Abstract

A secure computer controlling access to internal devices via an integrated card reader. A microprocessor-controlled card reader interface logically connected to the CPU of the computer reads and writes information from and to a card placed in the card reader and performs additional functions in response to commands received from the CPU. The boot ROM of the computer is programmed to start execution from a program logic device which runs a verification program to verify the authenticity of a user. Upon a valid user card being placed in the card reader, one or more questions are read from the card and displayed to the user. The user's responses are saved and compared to the correct answers stored on the card, and if the responses match the correct answers, a power control circuit is used by the CPU to turn on power to computer peripherals the user has been authorized to use.

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PROTECTING PROGRAMS AND DATA WITH CARD READERField of the Invention

The present invention pertains generally to
5 integrated circuit (IC) information card systems, and
more particularly to a microprocessor-controlled card
reader interface for controlling user access to the
components of a secure computer.

Background of the Invention

10 The power and flexibility of personal computers
has seen a tremendous growth in their use in all areas
of our society, including applications where the data is
sensitive in nature. Traditionally, these applications
have been found within agencies of the federal
15 government, but the highly competitive marketplace has
made such information as marketing, financial, and
business plans equally as sensitive to companies who
compete against each other in the commercial sector as
well.

20 In the early years of the industry when
computers were large mainframes, it was relatively easy
to control access to them simply by controlling physical
access to the room they were contained in. Since modern
personal computers are much smaller and may in fact be
25 designed to be carried with a user, it is much more
difficult to prevent unauthorized access while still
maintaining the advantage of portability.

While it is possible through a software program
running on the computer to require a user to enter a
30 password or other verification code, this method is not
robust in that a password may be guessed, or the
software program may be bypassed by commercially
available software development tools. Other security
methods involving various hardware devices or keys have
35 been proposed and implemented, but they too suffer from
the disadvantage that a sufficiently knowledgeable and
persistent user may gain unauthorized access to data by
tapping into the computer's operating system with
specially designed software programs. For applications

with particularly sensitive data, it may also be desirable to provide a way to physically and logically destroy the data before it becomes compromised.

Therefore, there is a need to have a convenient way to prevent the unauthorized use of a computer system which is not subject to bypass while still maintaining the portability and flexibility of the computer system. There is an additional need to provide a way to authorize users to use the computer system. There is a further need to physically and logically destroy data in response to unauthorized attempts by a user to violate the physical or logical integrity of the computer system.

Summary of the Invention

The present invention provides for a secure computer controlling access to internal devices via an integrated card reader. A microprocessor-controlled card reader interface logically connected to the CPU of the computer reads and writes information from and to a card placed in the card reader and performs additional functions in response to commands received from the CPU. The boot ROM of the computer is programmed to start execution from a program logic device which runs a verification program to verify the authenticity of a user. Upon a valid user card being placed in the card reader, one or more questions are read from the card and displayed to the user. The user's responses are saved and compared to the correct answers stored on the card, and if the responses match the correct answers, a power control circuit is used by the CPU to turn on power to computer peripherals the user has been authorized to use.

According to an additional aspect of this invention, the system provides for a method of initializing and authorizing a user card with a security administrator card. Upon a valid security administrator card being placed in the card reader, a security

administrator initializes and authorizes one or more individual user cards by selecting from a list of menu options displayed to the security administrator. The security administrator inputs a list of questions and
5 answers which are then stored on the user card for use during the verification procedure.

According to a further aspect of this invention, the system provides for the physical and logical destruction of data in response to unauthorized
10 attempts by a user to violate the physical or logical integrity of the computer system. The physical and logical destruction of data may be disabled for maintenance or configuration purposes by the use of a maintenance card.

15 The preceding and other features and advantages of the invention will become further apparent from the detailed description that follows. This description is accompanied by a set of drawing figures. Numerals are employed throughout the written description and the
20 drawings to point out the various features of this invention, like numerals referring to like features throughout.

Brief Description of the Drawings

Figure 1 is a perspective view of a secure
25 computer system according to the present invention.

Figure 2 is a block diagram showing the high-level architecture of a secure computer system according to the present invention.

Figure 3 is a schematic diagram showing the
30 microprocessor-controlled card reader interface for a secure computer system according to the present invention.

Figure 4 is a flow diagram showing the steps taken to read and write information from and to a card
35 according to the present invention.

Figure 5 is a flow diagram showing the steps taken to verify a user according to the present invention.

Figure 6 is a flow diagram showing the steps taken to authorize a user according to the present invention.

Figure 7 is a flow diagram showing the steps taken to deactivate the physical and logical destruction of data according to the present invention.

10 Detailed Description of the
 Preferred Embodiments

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific
15 embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

20 The following is a list of reference numerals and descriptions corresponding to the numerals employed in the accompanying set of drawing figures.

NUMERALS AND DESCRIPTIONS

25	101	keyboard
	103	computer chassis
	105	screen display
	107	pointing device
	109	card reader interface
30	111	integrated card reader
	113	integrated circuit (IC) card
	115	microprocessor
	117	second data bus
	119	power control circuit
35	121	peripheral devices
	123	central processing unit (CPU)
	125	system data bus
	126	boot rom
	127	random access memory (RAM)
40	129	program logic device (PLD)
	131	third data bus
	133	fourth data bus
	135	power circuit
	137	clear
45	139	+5 volt lithium battery

- 141 address or data select
- 143 strobe
- 145 chip select
- 147 clear to send (CTS)
- 5 149 data terminal ready (DTR)
- 151 10 MHz clock
- 153 serial data out
- 155 serial data in
- 157 3.5 MHz clock
- 10 159 card reset
- 161 card serial data control
- 163 card interrupt control
- 165 physical destruct
- 167 card serial data in
- 15 169 card serial data out
- 171 card power control switch
- 173 card power control line
- 175 +5 volt relay
- 177 card serial data contact
- 20 179 card clock contact
- 181 card reset contact
- 183 card logic voltage supply contact
- 185 card ground contact
- 187 card programming contact
- 25 189 card detect contact
- 191 card detect power contact
- 193 reserved for future use
- 195 reserved for future use
- 197 reserved for future use

30 DETAILED DESCRIPTION

Figure 1 shows the components of a computer system to be secured with a card reader interface. The computer system includes a keyboard 101 by which a user may input data into the system, a computer chassis 103 which holds electrical components and peripherals, a screen display 105 by which information is displayed to the user, and a pointing device 107, the system components logically connected to each other via the internal system bus of the computer. A card reader 111 is connected to the secure computer system via card reader interface 109. The preferred card reader 111 is an Amphenol® "Chipcard" acceptor device, part number C 702 10 M 008 103 4, which is compatible with International Standards Organization (ISO) specification 7816, although one skilled in the art would readily recognize that other card reader devices which conform to ISO 7816 may be substituted.

In order for the computer system to be secured, a card reader interface is integrated into the computer system in a manner similar to that as revealed in Figure 2. A card reader interface board 109 contains a
5 microprocessor 115 connected to the CPU of the computer via a second data bus 117, connected to RAM 127 via a third data bus 131, and connected to the card reader 111 via a fourth data bus 133. The interface board 109 is typically implemented with printed circuit board
10 technology, although other equivalent technologies may be substituted without loss of generality. Peripherals 121 within computer 103 are controlled by the CPU 123 and PLD 129 with a power control circuit 119, which turns power off and on to peripherals 121. A system
15 boot ROM 126 logically connected to the CPU 123 via system data bus 125 is programmed to instruct the CPU 123 to start executing a non-volatile program contained in PLD 129 upon power-up, clear, or warm-boot reset of the computer.

20 An IC card 113 is used in conjunction with card reader 111. The preferred IC card 113 is a MICRO CARD[®] model SCOT 100 or model TB100 IC card, which is compatible with ISO standards 7810, 7813, and 7816. By conforming to these standards, the IC card 113 provides
25 support for Data Encryption Standard (DES) data encryption and decryption functions. One skilled in the art would readily recognize that other IC cards which conform to these standards and provide data encryption and decryption functions may be substituted. The
30 ability to encrypt and decrypt data is important, since the present invention is designed to never allow unencrypted security data to exist on the CPU where it could be subject to compromise by a malicious user.

The schematic for card reader interface 109 is
35 described in greater detail in Figure 3. Microprocessor 115 is powered by circuit 135, and controls system functions via connections to the system data bus 125.

System resets are initiated by clear line 137.

Validation and authorization information is transferred between the microprocessor 115 and RAM 127 via the third data bus 131 in conjunction with address or data select

5 line 141, strobe line 143, and chip select line 145.

Backup power is provided for RAM 127 by a +5 volt lithium battery 139.

The microprocessor 115 communicates with system data bus 125 as a serial communications device using CTS
10 line 147, DTR line 149, 10 MHz clock line 151, serial data out line 153, and serial data in line 155. A separate 3.5 MHz clock line 157 is used to provide a clock signal to PLD 129, which is used by the microprocessor 115 for card reset control via line 159,
15 card serial data control via line 161, and card interrupt control via line 163. The PLD 129 in turn connects to the card via card serial data contact 177, card clock contact 179, and card reset contact 181. The microprocessor 115 also has the ability to control
20 the physical destruction of data within the computer system via line 165. The line connects to a mechanism containing a chemical solution which is sprayed onto a hard disk contained in the secure computer system in response to unauthorized attempts by a user to violate
25 the physical or logical integrity of the computer system. The preferred chemical solution is that of ferric chloride, however, one of ordinary skill in the art would recognize that other equivalent destruction chemicals and mechanisms may be substituted without loss
30 of generality.

The microprocessor 115 uses power control line 173 with switch 171 and +5 volt relay 175 to provide power to the card via card logic voltage supply contact 183 and card programming contact 187. The card is
35 grounded via card ground contact 185, and detected by power being applied through card detect power contact 191 to microprocessor 115 by card detect contact 189.

Card contacts 193 and 195 and line 197 are reserved for future use.

As illustrated by the method of Figure 4, the microprocessor 115 works in conjunction with CPU 123 running under program control of the PLD 129 in order to perform functions involving the card 113. The microprocessor 115 runs in an infinite loop interpreting and performing commands sent to it by the CPU 123. At 201, the microprocessor 115 is started by either a computer system power-up, a system clear, or a system warm-boot. At 203, a hardware interrupt is asserted on the system bus, the current status is sent to the CPU at 205, and at 207 the microprocessor 115 waits for a command to be received from the CPU 113. Upon receipt of a valid command 211, the command is processed at 209 and control returns to 207. The list of valid commands interpreted by the microprocessor 115 includes but is not limited to:

1. Clear
2. Card Power On
3. Card Power Off
4. Write Validation
5. Read Card
6. Read Card Encrypted
7. Write Card
8. Write Card Encrypted
9. Erase Card
10. Remove Card - No Clear
11. Wake-Up Call

Figure 5 shows the steps taken by the CPU 123 and microprocessor 115 in order to verify the authenticity of a user of the secure computer system. At 213, the microprocessor waits for a valid user card to be inserted into the card reader, and at 215 the CPU waits for the microprocessor to send a card type status code. If no card type is received, control returns to 213. If at 215 a card type is received, it is checked for validity at 217. If the card type is invalid, a status message is displayed to the user at 219 and control returns to 213. If at 217 the card type is valid, a question is read from the card at 221,

displayed to the user at 223, and the CPU waits for a user response at 225. Once the CPU receives a response from the user, the response is sent to the microprocessor at 227. The microprocessor compares the user response to the correct response stored on the card, and returns a compare status to the CPU at 229. This step is performed solely by the microprocessor so that unencrypted security data is never available to the CPU. If at 231 the compare status indicates a non-matching response, a retry counter is incremented at 233 and checked at 235 to see if it is less than a predetermined maximum allowed value. If the value of the retry counter is less than the maximum allowed value, control returns to 225, otherwise the secure computer system is rebooted at 237. If at 231 the compare status indicates a matching response, at 239 the CPU uses power control circuit 119 to turn on power to the secure computer system peripherals that the user has been authorized to use. Such peripherals might include, but are not limited to, a floppy disk drive, a hard disk drive, serial port, parallel port, and internal modem depending on the configuration of the secure computer system.

In an alternative embodiment, access to specific directories on a hard disk is enabled by IC card 113. A DES encryption chip attached to system data bus 125 is used with a modified version of the secure computer system basic input/output system (BIOS) to encrypt the information and files stored in a specific subdirectory with a key value. The key value for each subdirectory the user has access to is stored on the IC card 113. Upon successfully completing the verification procedure described above and shown in Figure 5, the key values for the subdirectories are read from the IC card 113 and used by the BIOS and DES chip to encrypt and decrypt information and files as needed by the user. If directory creation is allowed for the user, a personal

user key is used to encrypt and decrypt the new directory and all information and files contained within it.

The procedure used by a security administrator to authorize a user is revealed in Figure 6. At 241, the microprocessor waits for a valid administrator card to be inserted into the card reader, and at 243 the CPU waits for the microprocessor to send a card type status code. If no card type is received, control returns to 241. If at 243 a card type is received, it is checked for validity at 245. If the card type is invalid, a status message is displayed to the operator at 247 and control returns to 241. If at 245 the card type is valid, an authorization code is read from the card at 249, the operator is prompted for the code at 251, and the CPU waits for an operator response at 253. Once the CPU receives a response from the operator, the response is sent to the microprocessor and compared with the authorization code at 255. If at 257 the compare status indicates a non-matching response, a retry counter is incremented at 259 and checked at 261 to see if it is less than a predetermined maximum allowed value. If the value of the retry counter is less than the maximum allowed value, control returns to 253, otherwise the secure computer system is rebooted at 263. If at 257 the compare status indicates a matching response, at 265 the CPU waits for the administration card to be removed, displays a list of menu options to the operator at 267, and waits for an operator selection at 269.

The list of menu options includes but is not limited to exit, initialize card, and process security. If at 269 the operator selects exit, the program terminates and no further action is taken. If at 269 the operator selects initialize card, at 289 the CPU waits for a valid administrator card to be inserted into the card reader, gets an authorization code from the card at 291, and compares the code to an operator

response at 293. If at 295 the code matches the response, the operator is prompted to insert a valid user card at 297, and the user card is initialized at 299, otherwise control continues at 301. At 301 the
5 operator is prompted to remove the card and the CPU then waits at 303 for the card to be removed. If at 305 there are no more cards to be initialized, control returns to 269, otherwise control returns to 289.

If at 269 the operator selects process
10 security, at 271 the CPU waits for a valid administrator card to be inserted into the card reader, gets an authorization code from the card at 273, and compares the code to an operator response at 275. If at 277 the code does not match the response, control continues at
15 301. Otherwise, the operator is prompted to enter a list of questions and answers at 279, the CPU waits for an operator response at 281, then prompts the operator for the user card at 283. At 285 the user card is erased, the questions and answers and other information
20 is written to the card at 287, and control continues at 301.

The secure computer system physically and logically destroys data within the system in response to unauthorized attempts by a user to violate the physical
25 or logical integrity of the computer system. In order to deactivate this system in order to perform system maintenance or change the system configuration, a maintenance card is used with the procedure described in Figure 7. At 307 the CPU waits for a valid
30 administrator card to be inserted into the card reader, gets an authorization code from the card at 309, and compares the code to an operator response at 311. If at 313 the code does not match the response, control returns to 307. Otherwise, upon detecting a valid
35 maintenance card at 315, at 317 the CPU disables the physical destruction of data and clears RAM 127, then reboots the system at 319. The system may now be safety

shut down for maintenance. Physical and logical destruction of data are automatically reenabled upon the next time the system is restarted after maintenance or configuration is performed.

5 It is to be understood, however, that even though numerous characteristics and advantages of the invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is
10 illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention, to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

WHAT IS CLAIMED:

1. A secure computer providing for the controlled access of internal devices via an integrated card reader, the computer comprising:

- 5 a user input device;
- an integrated card reader;
- a screen display;
- a central processing unit (CPU);
- a program logic device (PLD) containing non-
- 10 volatile CPU program code;
- a CPU system boot from the PLD;
- a plurality of peripheral devices;
- a system data bus;
- a microprocessor for writing and reading
- 15 information to and from a card placed in the card reader;
- a second data bus logically connected between the microprocessor and the CPU and separate from the system data bus; and
- 20 a power control circuit logically connected between the CPU and each of the plurality of peripheral devices for selectively controlling power to each of the plurality of peripheral devices in response to information read from the card.

25

2. A secure computer providing for the controlled access of internal devices via an integrated card reader, the computer comprising:

- a user input device;
- 30 an integrated card reader;
- a screen display;
- a central processing unit (CPU);
- a program logic device (PLD) containing non-
- volatile CPU program code;
- 35 a CPU system boot from the PLD;
- a plurality of peripheral devices;
- a system data bus;

a microprocessor for writing and reading information to and from a card placed in the card reader;

5 a second data bus logically connected between the microprocessor and the CPU and separate from the system data bus;

a power control circuit logically connected between the CPU and each of the plurality of peripheral devices for selectively controlling power to each of the
10 plurality of peripheral devices in response to information read from the card; and

means operative to cause said CPU to perform the step of:

waiting for a valid card to be placed in the
15 card reader by the user;

reading at least one question from a list of questions stored on the card, displaying the question to the user on the screen display, and waiting for a response from the user on the input device;

20 comparing at least one user response to a list of correct answers stored on the card; and

allowing access to the computer if at least one user response matches a corresponding correct answer.

25 3. The computer of claim 2 wherein the CPU performs the additional step of incrementing the value of a retry counter if the user incorrectly answers a question, and waiting for a subsequent user response if the value of the retry counter is less than a
30 predetermined value, otherwise rebooting the computer.

4. A secure computer providing for the controlled access of internal devices via an integrated card reader, the computer comprising:

35 a user input device;
an integrated card reader;
a screen display;

a central processing unit (CPU);
a program logic device (PLD) containing non-volatile CPU program code;
a CPU system boot from the PLD;
5 a plurality of peripheral devices;
a system data bus;
a microprocessor for writing and reading information to and from a card placed in the card reader;
10 a second data bus logically connected between the microprocessor and the CPU and separate from the system data bus; and
a power control circuit logically connected between the CPU and each of the plurality of peripheral
15 devices for selectively controlling power to each of the plurality of peripheral devices in response to information read from the card.
program control means operative to cause the CPU to perform the authorization steps of:
20 waiting for a valid security administrator card to be placed in the card reader by an operator;
reading at least one authorization code from the security administrator card, prompting the operator for the authorization code, and waiting for a response
25 from the operator;
comparing at least one operator response to the authorization code read from the card;
prompting the operator to remove the valid security administrator card and waiting for the card to
30 be removed if all operator responses match a corresponding authorization code;
displaying a list of options to the operator via a main menu, prompting the operator to select an option, and waiting for a response from the operator;
35 and
performing the function corresponding to the option selected from the main menu by the operator and

returning control back to the main menu.

5 5. The computer of claim 4 wherein the list
of options comprises exit, initialize secure card, and
process security.

6. The computer of claim 4 wherein if the
operator selects exit, the authorization steps terminate
with no further steps performed.

10

7. The computer of claim 4 wherein the
program control means includes means operative when the
operator selects initialize secure card to cause the CPU
to perform the additional authorization steps of:

15 prompting the operator to insert a valid user
card and waiting for a valid user card to be inserted;
reading at least one authorization code from
the user card, comparing the card authorization code to
the operator authorization code, and if the card has
20 been previously used and the authorization codes do not
match:

(i) . prompting the operator to remove the
user card and waiting for the card to be
removed;

25 (ii) returning control back to the main
menu;

erasing any information previously stored on
the user card and writing the operator authorization
code to the card; and

30 prompting the operator to remove the user card,
waiting for the card to be removed, and returning
control back to the main menu.

8. The computer of claim 4 wherein the
35 program control means includes means operative when the
operator selects process security to cause the CPU to
perform the additional authorization steps of:

prompting the operator to insert a valid user card and waiting for a valid user card to be inserted; reading at least one authorization code from the user card, comparing the card authorization code to the operator authorization code, and if the
5 authorization codes do not match:

- (i) prompting the operator to remove the user card and waiting for the card to be removed;
- 10 (ii) returning control back to the main menu;

prompting the operator for questions to ask the user and answers to the questions, and waiting for a response from the operator to all prompts;
15 erasing any information previously stored on the user card and writing the operator authorization code, questions, and answers to the card; and
prompting the operator to remove the user card, waiting for the card to be removed, and returning
20 control back to the main menu if there are no more user cards to be authorized, otherwise looping until all remaining user cards are authorized.

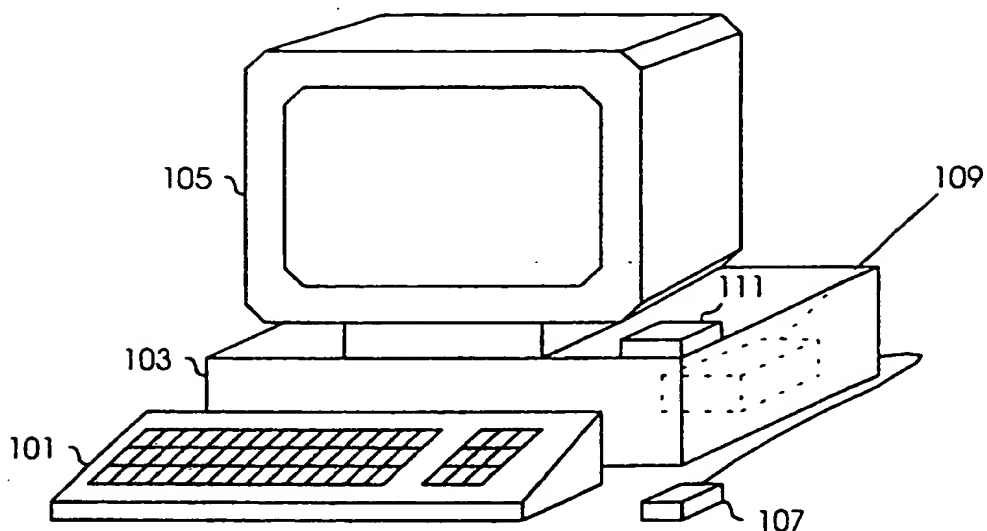
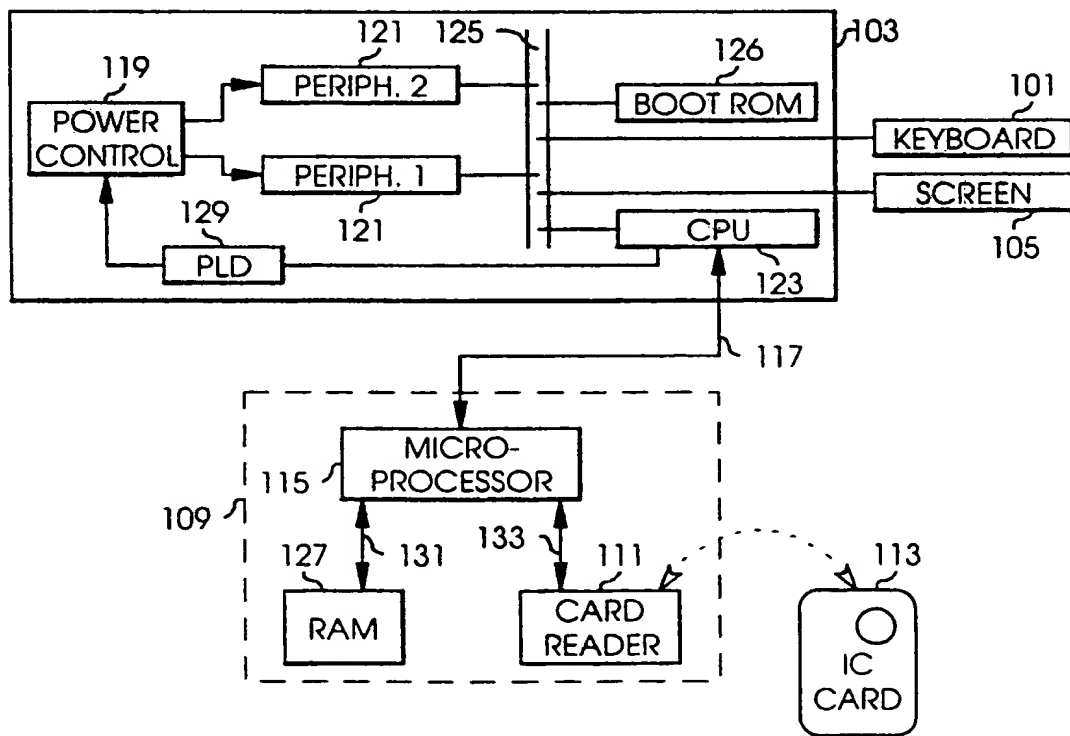
9. A secure computer comprising:
25 a user input device;
an card reader;
a screen display;
a microprocessor for reading information from a card placed in the card reader; and
30 a circuit to control the operation of said computer to prevent unauthorized access.

10. A method of controlling access to a computer including
35 a user input device,
an card reader,
a screen display and

a microprocessor for reading information from a card placed in the card reader, the method comprising the step of:

- 5 reading information from the card and using it to prevent unauthorized access to the computer.

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*Fig. 1**Fig. 2*

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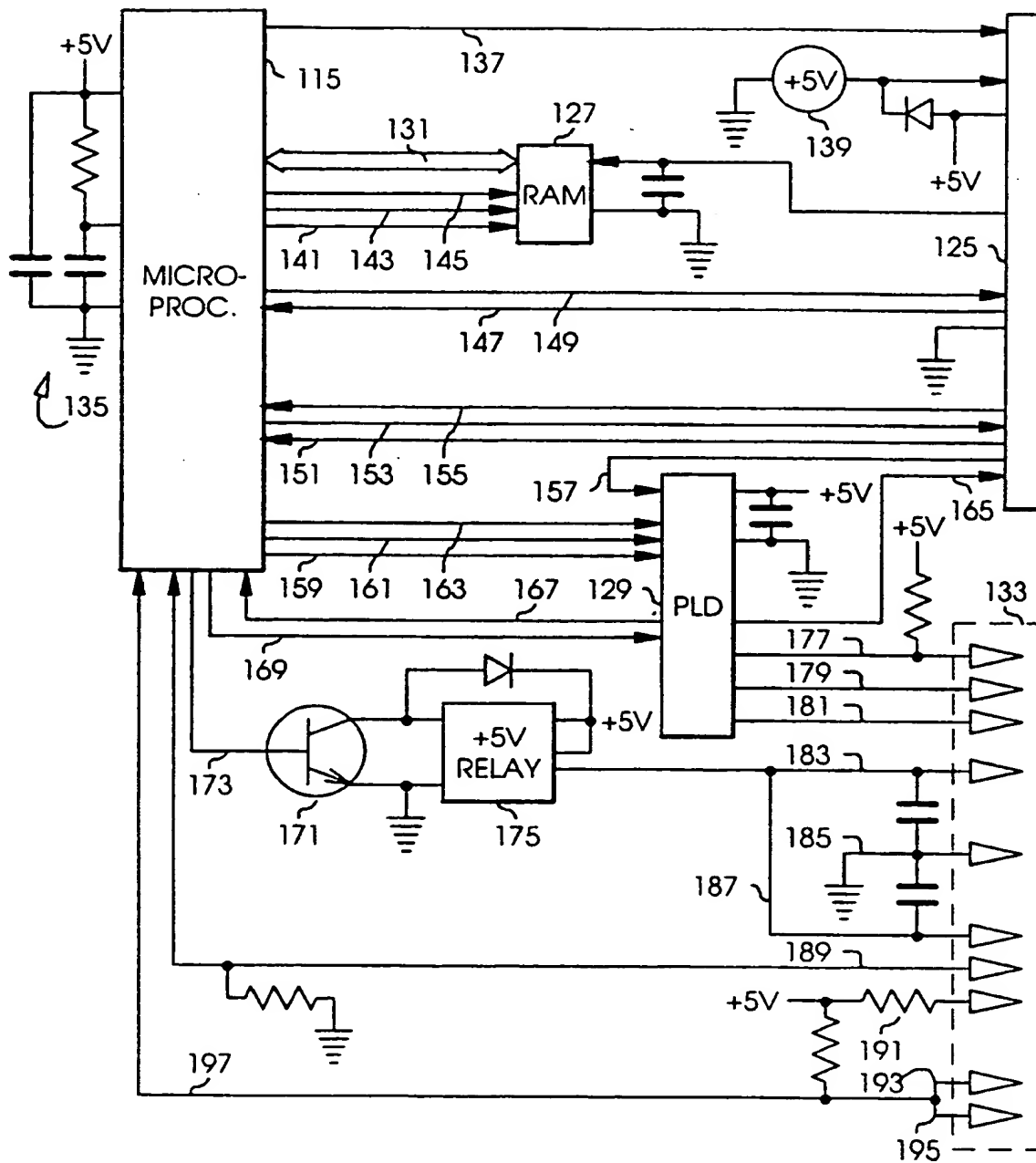
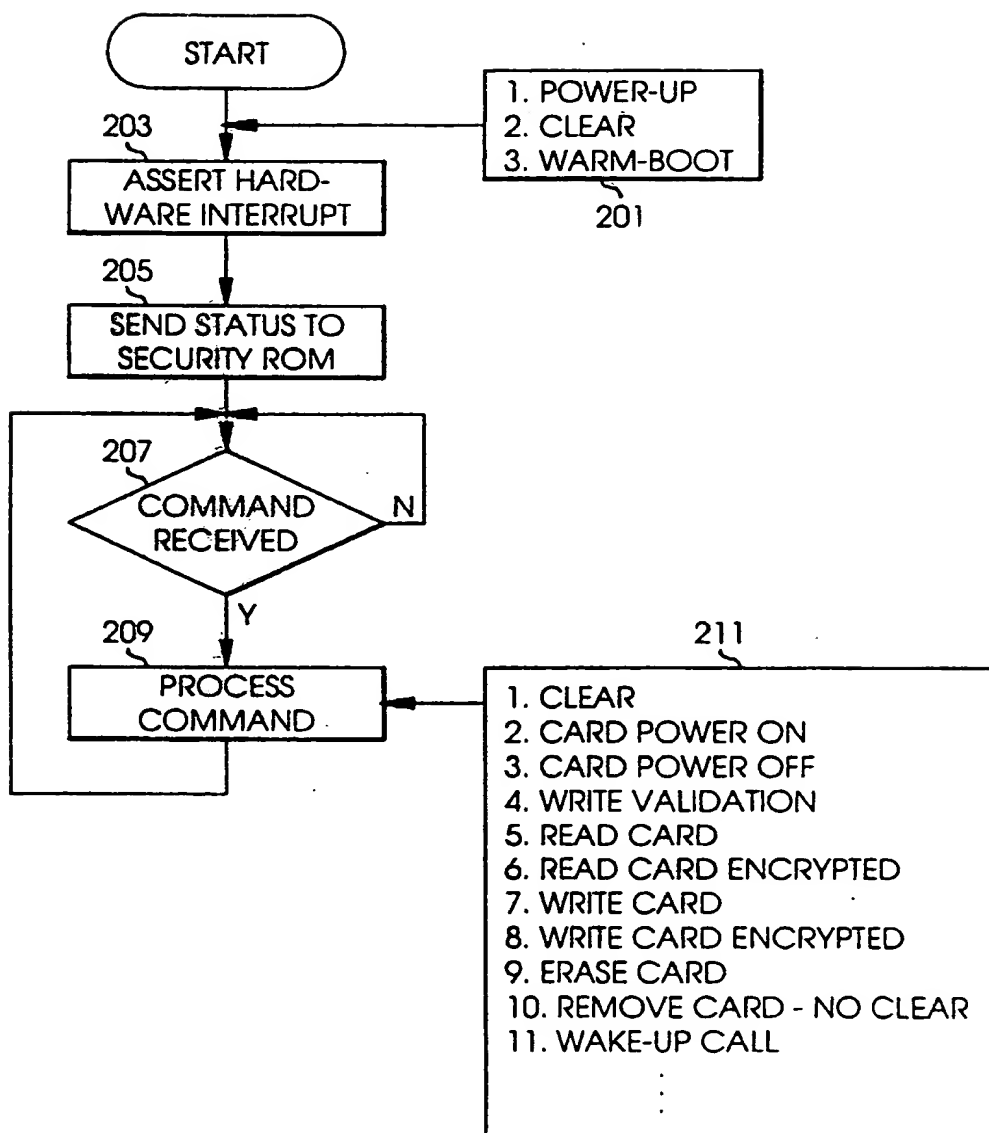
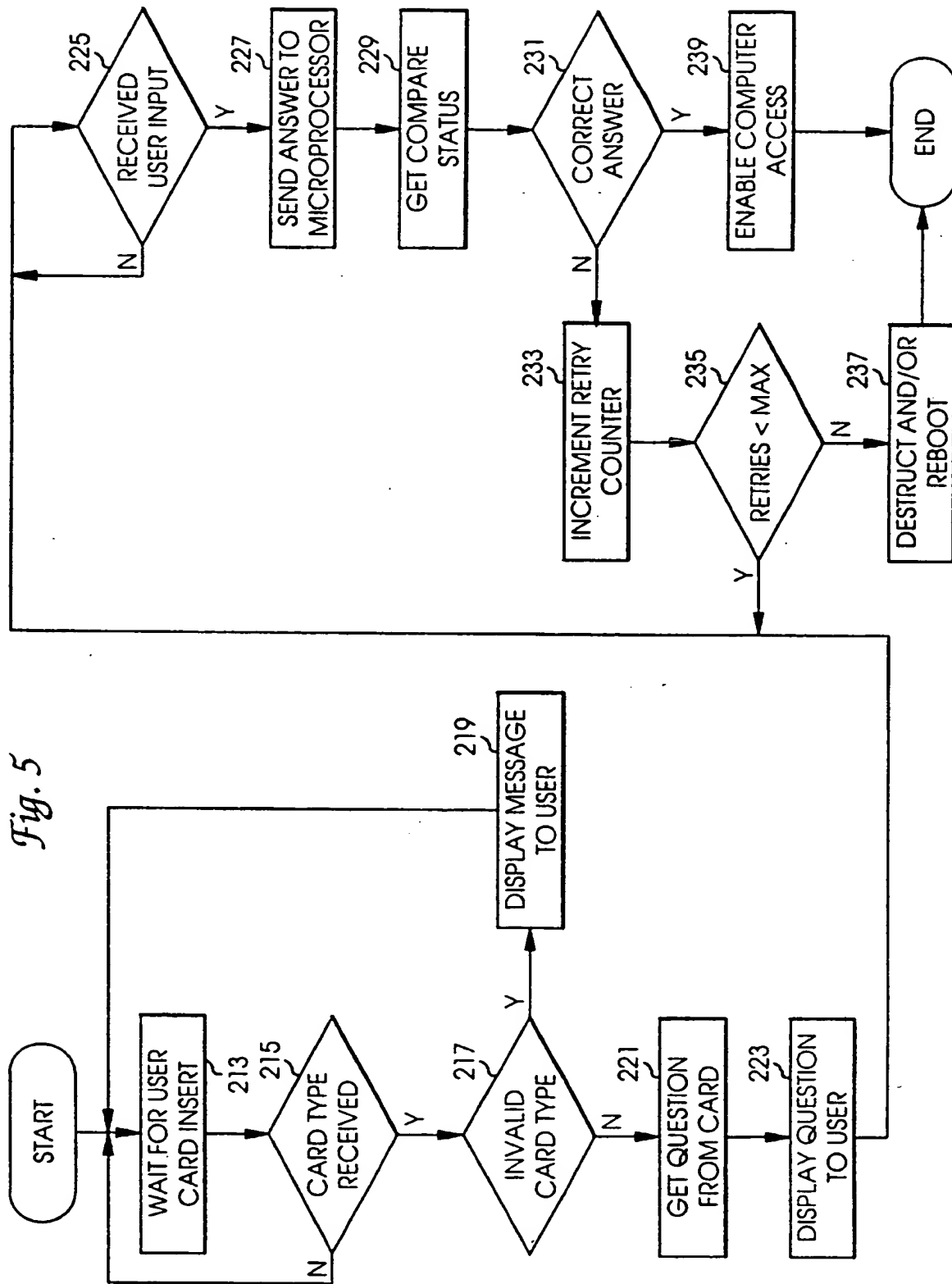


Fig. 3

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*Fig. 4*



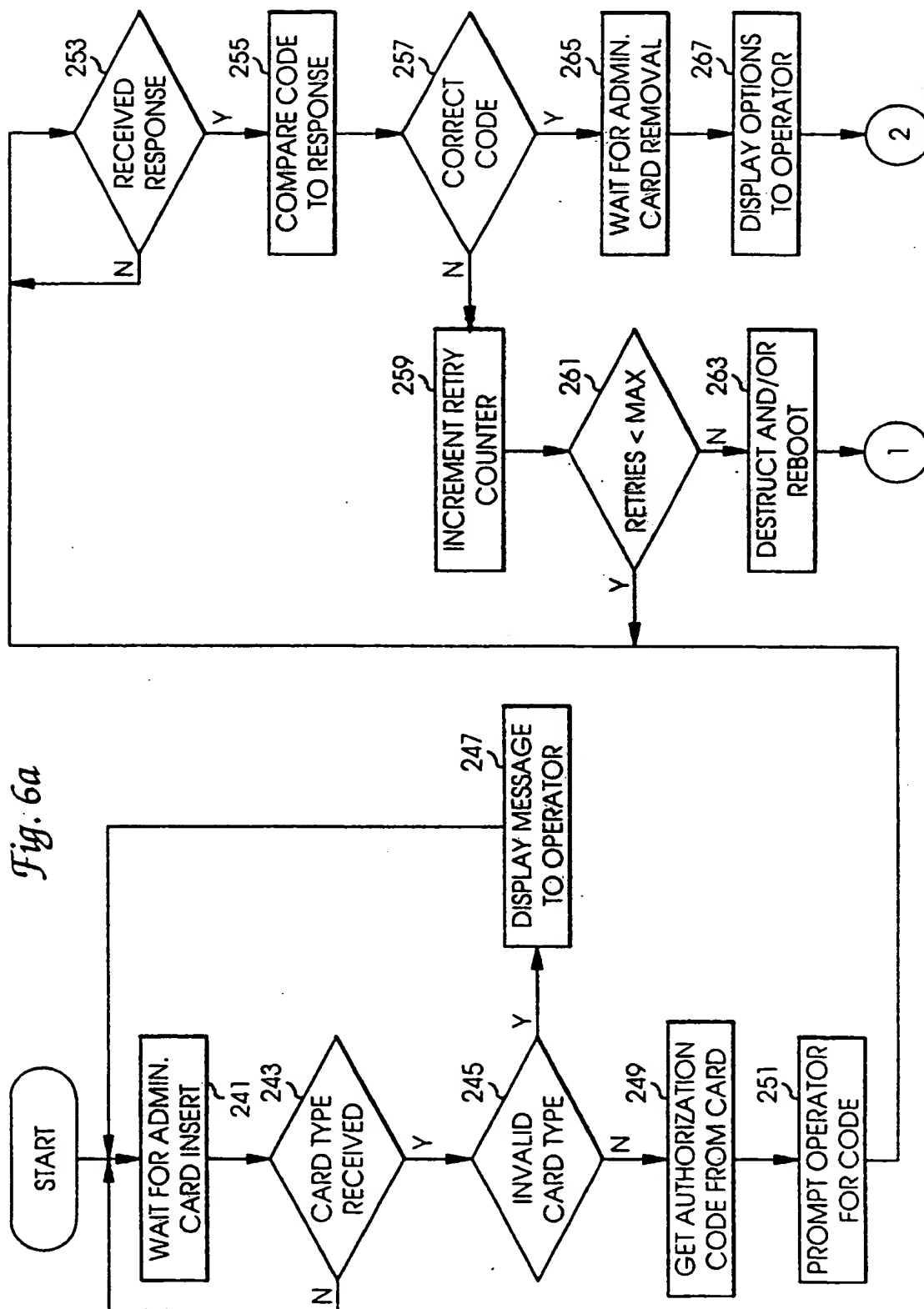
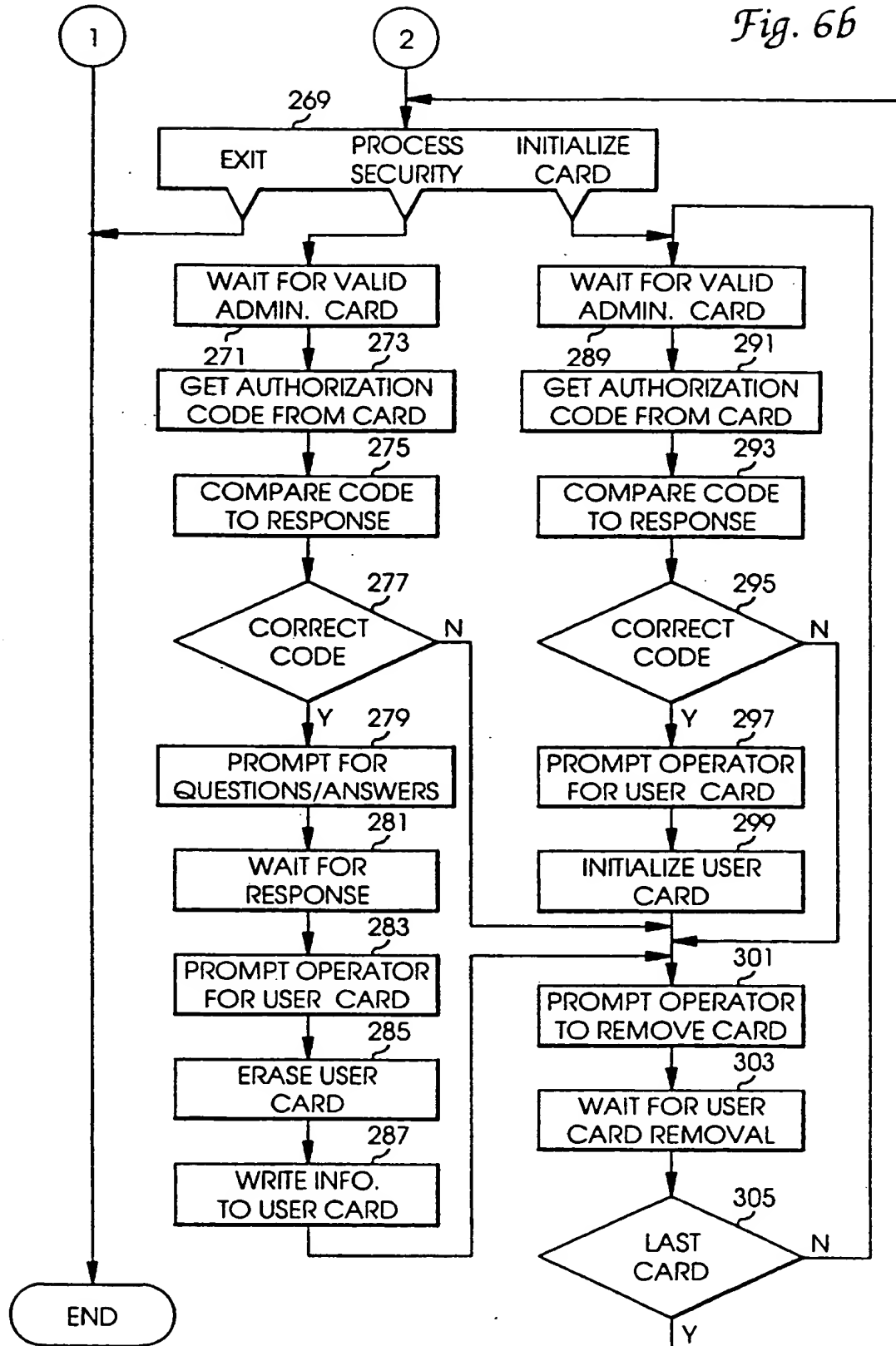
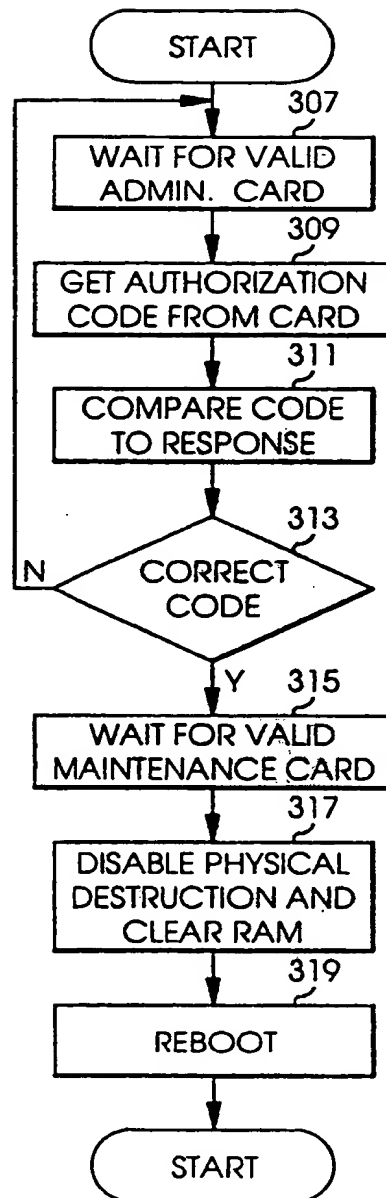


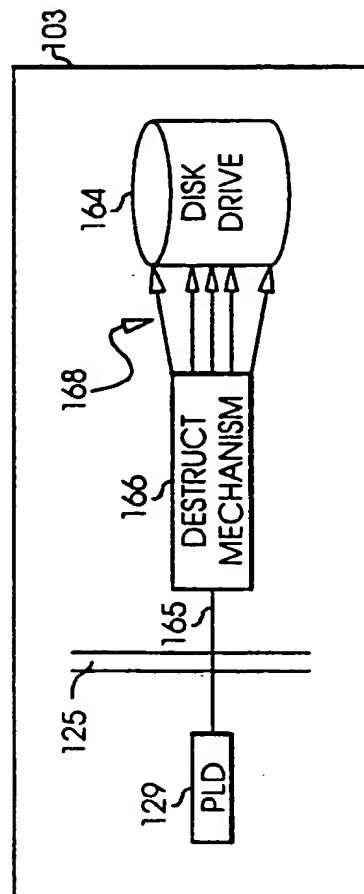
Fig. 6b



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*Fig. 7*

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*Fig. 8*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 93/05357

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G07F7/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 G07F G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 170 716 (TOSHIBA) 12 February 1986 see abstract ---	1,2,4
A	EP,A,0 458 614 (NEC CORPORATION) 22 May 1990 see abstract ---	1,2,4
A	GB,A,2 112 190 (OMRON TATEISI ELECTRONICS) 13 July 1983	1,2,4
X	see page 2, line 63 - line 75 see page 3, line 52 - line 65 see line 85 - line 94 see claim 1 --- -/--	9,10

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

6 October 1993

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 93/05357

C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP,A,0 262 025 (FUJITSU) 30 March 1988 see abstract ---	1,2,4
A	EP,A,0 182 244 (OKI ELECTRIC INDUSTRY COMPANY) 28 May 1986 see abstract see page 28, line 28 - page 33, line 16 see claim 1 ---	1,2,4
A	EP,A,0 190 733 (TOSHIBA) 13 August 1986 see abstract see page 4, line 22 - page 8, line 13 ---	1,2,4
A	GB,A,2 112 190 (OMRON TATEISI ELECTRONICS) 13 July 1983 see abstract -----	1,2,4

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